Using Plants to Remediate Petroleum-Contaminated Soil - Project Continuation – Quarterly Report

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Period Covered by the Report: October 1, 2002 to January 1, 2003
Date of Report: 3/15/2001
EPA Grant Number: R827015-01-0
Title: Using Plants to Remediate Petroleum-Contaminated Soil - Project Continuation
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EPA Project Officer: Bala Krishnan
Project Period: July 1, 2001 to June 30, 2002 (N/C extension till May 15, 2003)
Project Amount: $145,298
Research Category: Phytoremediation

This report covers the October 1, 2002 to January 1, 2003 period and summarizes our current IPEC phytoremediation studies that consist of an on-site field project in southern Arkansas and a mathematical modeling project.

Progress Summary/Accomplishments:

Field Study

Materials and Methods

The field site in El Dorado, AR is located in a bermed crude oil storage/separation facility that was the site of an intentional spill in 1997 by vandals. The experimental plots consist of four replicates of the following treatments: (1) nonvegetated-nonfertilized control, (2) ryegrass (*Lolium multiflorum L.*) - fescue (*Festuca arundinacea Schreb.*) + fertilizer, and (3) bermudagrass (*Cynodon dactylon (L.) Pers.*) - fescue + fertilizer. Each field plot has 12 microplots (>soil socks=) that contain homogenized soil that allow monitoring of the field treatments, on a smaller scale, with less effect of field variability of the contaminant levels.

Winter sampling of the field site at El Dorado, AR collected 6 January 2003 at 36 months after plot establishment and data for plant root biomass, root length, soil nutrient levels, and soil TPH levels are being processed. The spring sampling is scheduled for May 2003 (t=40 mo). Analyses for microbial parameters and shoot biomass are complete and statistical evaluation is underway.

Results and Discussion

Analysis of the soil samples collected 30 months after plot establishment shows the increase in nutrient levels and pH resulting from addition of fertilizer and lime (Table 1). The fertilized plots contained nutrient levels sufficient for plant growth.

For soil samples collected at 36 months, the microbial numbers show that bacterial and fungal numbers were greater in the vegetated-fertilized plots compared to the control plots (Fig. 1). There was no apparent difference between the fescue and bermudagrass treatments for bacterial or fungal numbers and numbers were within ranges expected for petroleum-contaminated soils. The number of petroleum- and alkane-degrader microorganisms suggested that levels were not different among the

three treatments at the 36-month sampling (Fig. 2). Numbers were consistent with previous observations for the plots.

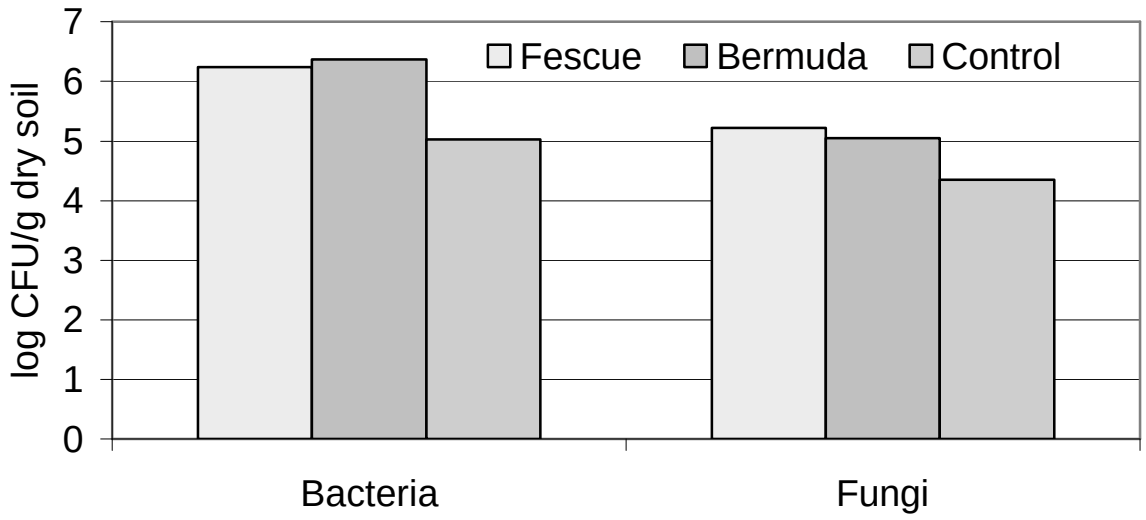

Fig. 1. Bacterial and fungal numbers for soil samples collected 36 months after plot establishment at the El Dorado field site. The control treatment was not fertilized and vegetation was eliminated. The fescue and bermudagrass plots received fertilizer and lime to facilitate plant growth.

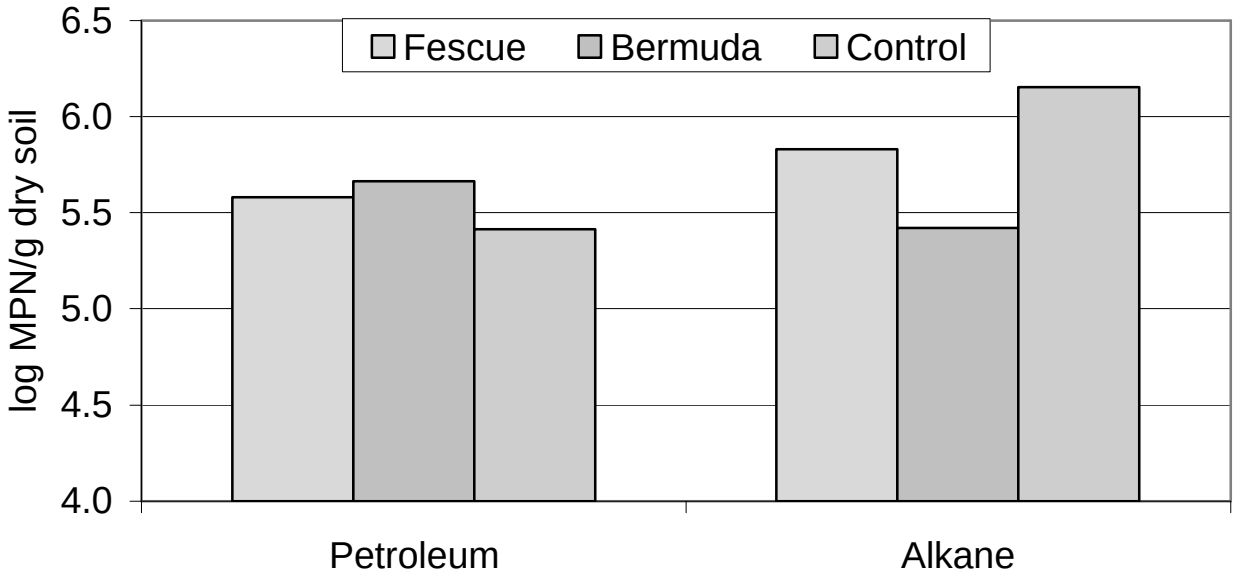

Fig. 2. Petroleum- and alkane-degrader microbial numbers for the three treatments at the El Dorado field site for samples collected 36 months after plot establishment. The numbers were similar across treatments and consistent with previous observations.

Publications/Presentations:

Abstracts and titles of poster or oral presentations given during this quarter include:

Thoma, G., D. Wolf, T. Lam, and S. Ziegler. Mathematical modeling of phytoremediation of

petroleum contaminated soils. *In* 9th Annual International Petroleum Environmental Conference. 22-25 October 2002. Albuquerque, NM.

Thoma, G., D.C. Wolf, T.B. Lam, and S. Ziegler. 2002. Mathematical modeling of phytoremediation of petroleum contaminated soils. *In* Annual Meetings Am. Inst. Chemical Engineers. 3-8 Nov. 2002. Indianapolis, IN.

White, Jr., P.M., G.J. Thoma, D.C. Wolf, and E.E. Gbur. 2002. Field scale phytoremedation of petroleum-contaminated soil. *In* 9th Annual International Petroleum Environmental Conference. 22-25 October 2002. Albuquerque, NM.

White, Jr., P.M., D.C. Wolf, G.J. Thoma, C.M. Reynolds, and E.E. Gbur. 2002. Effects of plants and fertilizer on the remediation of crude oil-contaminated soil. *In* Annual Meetings Abstracts [CD-ROM]. ASA, CSSA, SSSA, Madison, WI. (10-14 Nov. 2002. Indianapolis, IN).

Abstracts and titles that have been submitted for presentation as posters or presentations in the future include:

Greer, K.M., P.M. White, Jr., D.C. Wolf, G.J. Thoma, and S.E. Ziegler. 2003. Evaluation of field scale phytoremediation of crude oil-contaminated soil. *In* 87th Annual Meeting of Arkansas Academy of Science. 4-5 April 2003. Fayetteville, AR.

Manuscripts submitted:

Thoma, G.J., T.B. Lam, and D.C. Wolf. 2002. Modeling phytoremediation for petroleum contaminated soil: Model development. *Accepted Int. J. Phytoremed.*

Thoma, G.J., T.B. Lam, and D.C. Wolf. 2002. A mathematical model of phytoremediation for petroleum contaminated soil: Sensitivity analysis. *Accepted Int. J. Phytoremed.*

White, Jr., P.M., D.C. Wolf, G.J. Thoma, and C.M. Reynolds. 2003. Influence of organic and inorganic soil amendments on plant growth in crude oil-contaminated soil. *Accepted Int. J. Phyto.*

Future Activities:

Our initial findings suggest that phytoremediation does reduce contaminant levels through the action of microbial communities associated with the rhizosphere. It is therefore important to develop successful agronomic management strategies that exploit this understanding. However, our detailed knowledge of the microbial ecology of the rhizosphere is lacking. We plan to use carbon-13 isotopic labeling of specific contaminants coupled with phospholipid fatty acid (PLFA) analysis to identify specifically which class of microbes are responsible for the degradation. We will continue to investigate the modes of action of a phytoremediation system; while keeping in mind that the ultimate goal remains site cleanup.

The mathematical model will be extended to include climatic effects (specifically temperature and moisture level effects on kinetic degradation rate constants), so more site specific screening can be simulated.

Supplemental Keywords:

Rhizosphere; rhizodegradation; species selection; Arkansas; South Central United States

Relevant Web Sites:

Remediation Technologies Development Forum: **www.rtdf.org**; IPEC: **ipec.utulsa.edu**

Table 1. Chemical properties of the crude oil contaminated soil samples collected 28 September 2001 at T = 30 months of the field study in El Dorado, AR.

		----------Mehlich 3 Extractable----------					-----Total-----	
Treatment	pH	P	K	Ca	Mg	Na	C	N
	(2:1)	----------mg/kg----------					-------%-------	
Control No Fertilizer No Vegetation	5.7	8	65	532	70	70	4.063	0.065
Fescue/Rye + Fertilizer	5.9	23	90	856	137	107	3.953	0.095
Bermudagrass + Fertilizer	6.0	29	110	973	183	94	4.083	0.087